Very Preliminary Load Comparisons for Dissolved-mercury Species in South Bay

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Introduction

In the preliminary step of an ongoing study, we made the first direct measurements of dissolved mercury flux between the bottom sediments and the overlying water of South San Francisco Bay (South Bay). In May 2003, benthic flux of dissolved total mercury and dissolved methyl mercury were measured using a core-incubation technique used previously for other mercury studies (Kuwabara and others, 2002) and trace-metal studies in the Bay (Topping and others, 2001). Cores were taken from a deep, main-channel site (USGS Station 29a; Fig. 1) and from a western shoal station (25).

In contrast to typical management strategies which focus on particulate mercury that dominates total loads to the estuary, we concentrated on the dissolved, more bioavailable, species. Mercury has a very high affinity for binding with particles, but the mercury remaining in solution has the potential to be bioaccumulated and biomagnified up the food chain, potentially resulting in human-health fish consumption advisories (Abu-Saba and Tang, 2000).

Other ancillary parameters, including benthic community structure, dissolved organic carbon, sulfide, and nutrients are being studied as well, but will not presented until the field study is complete.

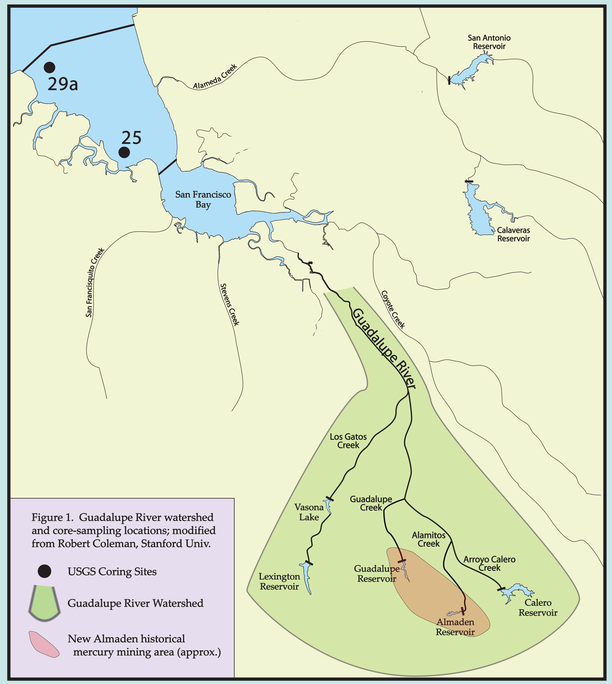

Figure 1. Guadalupe River watershed and core-sampling locations; modified from Robert Coleman, Stanford Univ.

Results

Dissolved Total-Hg Benthic Flux - From our initial experimental series, total-dissolved mercury fluxes averaged 42 and 89 pmoles/m2/hr at stations 25 and 29a, respectively. Similar studies done for mercury-impacted Sierra Nevada reservoirs (Kuwabara and others, 2002; Kuwabara and others, 2003) produced a range of values from 80 to 1600 pmoles/m2/hr.

Dissolved Methly-Hg Below Detection - All dissolved methyl-Hg concentrations were below analytical detection limits (< 0.1 ng/L); therefore we cannot determine methyl-Hg fluxes. Considering the relatively low dissolved total-Hg concentrations (~1-3 ng/L), and the typical ratio of dissolved total- to methyl-Hg (mostly >50) observed in our studies, these undetectable methyl-Hg values are not surprising.

Between-Site Differences (Flux and Methylation Potential) - The average benthic flux for our main-channel site (29a) was higher than our western-shoal site (25), although one replicate drove that difference (Fig. 2). Consistent with that difference between sites, a two-fold higher ratio of methylation to demethylation was measured via radiotracers at the deep, main-channel site. Specifically, shoal station 25 showed a potential methyl-Hg production rate of 4.1 ng/g-dry sediment/day and a potential methyl-Hg degradation rate of 8.7 ng/g/day. For main-channel station 29a, these values were 7.4 and 7.3, respectively. We hypothesize that the combination of tidal and wind effects allowed redox gradients near the sediment-water interface to be better maintained at the deeper main-channel site relative to the western-shoal site.

Load Comparisons

Data Scarcity - Let it first be said that there is a paucity of dissolved Hg and total Hg loading data for the South Bay. Although our interpretations are preliminary and subject to change as our study extends beyond its initial stages, we hope these results may contribute to the interest in mercury dynamics within the estuary.

Benthic Flux as Load - For purposes of comparison to loads, the South Bay flux values were converted to g/day (loading) by extrapolating these fluxes over the entire South Bay (south of the Bay Bridge) surface area (554 km2; Cheng and Gartner, 1985). The result is 116 and 246 g/day for stations 25 and 29a, respectively, for an overall average of **183** g/day of dissolved Hg into the bay.

Guadulupe Load Comparison - Hg-concentrations and river discharges were measured in a dry-season scenario (TetraTech, 2003) within the Guadalupe River watershed (which includes the New Almaden mining area, the largest historic mercury-producing mine in North America). The report calculated a range of **0.1-0.3** g/day of dissolved Hg for a late-July, low-flow condition. Although Hg measurements were not made during a high-flow storm in December 2002, assumptions were made based on the 3 orders of magnitude increase in flow. While particulate concentrations increase exponentially with flow, dissolved-Hg concentrations remain steady (presumably due to the balanced effects of dissolution, adsorption/desorption and dilution). Thus, let's assume that dissolved-Hg loads would increase in proportion to river discharge. These assumptions lead to a loading estimate of **100-300** g/day for dissolved Hg from the Guadalupe River during a high-flow event (Fig. 2). Additionally, data from Thomas and others (2002) can be used to calculate a load of 1.2 g/day of dissolved mercury during a lesser rain event in October 2000.

Implications of Episodic Precipitation - Based on the preliminary loading estimates, this comparison (Fig. 2) indicates that benthic flux from the sediment is **likely to be a dominant source** of dissolved Hg to the water-column particularly during the dry season (May-Oct). Furthermore, historic meteorological data (http://ggweather.com/sf/dailyprob.html) indicate that >90% of the days in the region are without significant precipitation, suggesting that benthic flux could also be important well beyond the dry season.

Management Considerations

If management directives focus solely on the inputs of particulate Hg, the effect of such policies on Hg accumulation in fish, and other higher trophic level organisms consumed by humans, is unclear. There is no evidence that particulate Hg is directly available for aquatic organisms to accumulate. Reducing all point-source inputs of Hg to the estuary may provide a very limited solution because 1) the benthic source could remain indefinitely, and 2) even pristine aquatic environments with no point source Hg inputs (U.S. EPA, 1997) have mercury-related fish consumption advisories. Consistent with that finding, S.F. Bay has similar advisories (Abu-Saba and Tang, 2000) despite dissolved methyl-Hg concentrations that are at times below detection limits, as observed in our initial sampling.

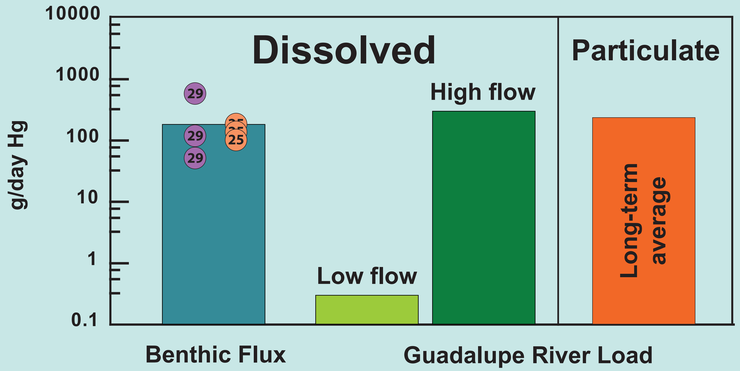

Figure 2: Comparison of Mercury loading estimates (Log scale):
Benthic flux of dissolved mercury, including individual core fluxes, compared to Guadalupe River loading of dissolved Hg for different flow events; Total Guadalupe River watershed particulate Hg load from long-term, annual average from Looker and Johnson (2003)

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